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HYBRID FIELD CORN

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CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN, CONNECTICUT

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HYBRID FIELD CORN

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Before hybrid corn came into general use, many different varieties of naturally-pollinated flint and dent corn were grown in Connecticut. Each section of the State and many individual farmers had their own selections of different strains, these often having long been grown in the same locality. Beginning in 1914, a study was made of these varieties. Seed was collected from the growers in the fall and compared in test fields at the Mt. Carmel Experimental Farm in the southern part of the State and at Storrs in the northeastern section. The results of this test, together with a description of the varieties grown, were published as Bulletin 259 of this Station in 1924 (12). Before this study was completed, hybrid corn was already in production and has since become so widely used that nearly all of the naturally-pollinated varieties of corn have entirely disappeared.

DEVELOPMENT OF HYBRID CORN

Hybrid corn resulted in part from investigations started at the Illinois Experiment Station before 1900 and transferred to the Connecticut Experiment Station in 1905. These investigations were greatly stimulated by the discovery, made by George H. Shull at the Carnegie Institution at Cold Spring Harbor, Long Island, New York, that a large amount of hybrid vigor resulted from crosses of inbred strains of corn. Shull demonstrated clearly the genetic variability of naturally cross-pollinated corn varieties and showed how these could be reduced to uniform, true-breeding strains by inbreeding. These inbred lines differed widely in all visible characters and were also unequal in their ability to transmit yield of grain and other desirable qualities. Inbred plants were generally weak and unproductive, but, when they were crossed, vigor and productiveness were restored to the maximum degree in the first generation following. For the first time, it was shown how valuable germplasm could be isolated and fixed so that it could be utilized to the fullest extent. This entirely new method of corn improvement involved such a radical change in methods of seed production that it made little headway at first. In time, however, the advantages to be gained were so apparent that the method is now used to produce practically all of the field corn seed planted in the main corn growing areas, is rapidly being extended to all of the corn grown in this country, and has also been applied to sweet corn and popcorn.

Early Investigations

It is of considerable interest to note the earlier investigations leading up to the crucial experiments that demonstrated the value of this new method of seed corn production.

Charles Darwin, in England, carried out an extensive series of experiments comparing cross-fertilized and self-fertilized plants of many species. Maize was one of the plants used. Single plants were isolated in a greenhouse and allowed to self-pollinate themselves naturally and other isolated plants

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were cross-pollinated. These results were reported in a book published in 1876 entitled "Cross and Self-fertilization in the Vegetable Kingdom". These results were known to Asa Gray, professor of botany at Harvard University, and to his student, William J. Beal. When Beal returned to the Michigan Agricultural College, one of his first experiments was to set up a crossing field of corn. He cross-fertilized corn plants by growing several varieties together in an isolated field and pulling out the tassels from all of the plants except one variety which was allowed to supply the pollen.

From a recent account by one of Beal's students at the Michigan Agricultural College, Perry G. Holden (7), Beal also self-fertilized corn plants by putting paper bags over the ear shoots and tassels and applying the pollen by hand at the right time. McCluer in 1892 (13) and Morrow and Gardner in 1893 (14) at the Illinois Experiment Station had made hand pollinations and compared crosses between different varieties and types of corn and had noted an appreciable hybrid vigor effect. In none of these experiments, however, had crosses of inbred plants been compared on a yield basis and no suggestion was made that inbreeding might have value for the production of high yielding corn.

Two of Beal's students, Eugene Davenport and Perry G. Holden, later director of the Experiment Station and head of the Department of Agronomy, respectively, at the Illinois College of Agriculture started an experiment on inbreeding corn at the Illinois Experiment Station in 1895. Plants of the Burr White variety were self-fertilized for at least four successive generations and showed the usual reduction in size, vigor and productiveness. These normal and inbred plants are shown growing in the field in a photograph published in DeVries "Plant Breeding" (3). The caption for this illustration states, erroneously, that the plants were growing on the breeding blocks of the Funk Brothers Seed Co., Bloomington, Illinois. According to Holden, he is the person shown in this photograph and he states that these plants were grown on the Illinois Station grounds. This and other photographs showing normal and inbred corn plants were published in a book by Bowman and Crossley on "Corn" (2) and in "The Book of Corn" (15). The chapters on corn breeding were written by A. D. and C. A. Shamel.

Holden also made crosses between ear-row progenies of naturally pollinated corn and found some of these to be higher yielding than the parental plants. He noted tall, vigorous plants in his inbred progenies. He assumed that these were accidental outcrosses and to prove this made crosses between different lots of inbreds. He found that "the plants were in great contrast in size and vigor to those from selfed seed".

These early experiments on inbreeding in Illinois established clearly that the immediate effects of inbreeding were highly injurious to corn and the efforts of these workers were directed towards methods of reducing and eliminating this harmful influence. There is no indication that these investigations would have resulted in hybrid corn as we know it today. The scientific analysis made possible by the work of Mendel and Johannsen, so ably applied by Shull, was needed to realize the possibilities of this radical departure in corn breeding methods.

The inbred lines started in 1895 under the direction of Director Eugene Davenport and Professor P. G. Holden were actually planted, cared for and pollinated by W. J. Frazer. Later, Holden was assisted by A. D. Shamel,

Claud Chapman and Jim Boyd as field workers. When Holden left the University of Illinois to work for the Illinois Sugar Refining Company, the corn breeding experiments were placed under the direction of C. J. Hopkins, assisted by L. H. Smith, W. T. Craig, H. H. Love and E. M. East. These assistants made the actual pollinations and carried out the details of the experiments.

The inbred strains of Leaming, a yellow-seeded variety quite distinct from Burr White, which were used in the production of Double Crossed Burr-Leaming were first grown as separate lines by E. M. East in Illinois in 1905. They were first grown in Connecticut in 1906 and continued as individual plant progeny lines to the present time by H. K. Hayes from 1910 to 1914 and from 1915 on by the senior writer. Whether these Leaming lines were separated from a bulked lot of previously inbred lines or started anew by East in 1905 is not positively known. All the records at the Connecticut Station show that these lines had been selfed once in Illinois before being transferred here. The yields of 38 to 61 bushels per acre obtained in Connecticut in 1906 compared to 88 bushels for the original variety in Illinois in 1905 indicate that these lines had not been inbred more than one or a few generations unless they had been accidently outcrossed. This latter possibility may have led East to treat these lines as one generation inbreds even though they came from bulked inbred lines that had been self-pollinated before 1905. In any case these Leaming lines were not out of the inbred Burr White material started by Holden in 1895.

The Double Cross

The first crosses of inbred strains made by Shull at the Carnegie Institution on Long Island and by East at the Connecticut Agricultural Experiment Station were not used commercially because they were low in yield and because the quality of the seed produced by them was inferior. To overcome these handicaps, the Double Cross method of combining four inbred strains

Figure 1. The crossing field used for the production of the Double Crossed Burr-Leaming hybrid in 1917 at the Mt. Carmel Farm.

by two successive crosses was developed and first applied in a crossing field in 1917 at the Mt. Carmel Farm of the Connecticut Agricultural Experiment Station. This method of producing seed was described in Station Bulletin 207 in 1918 (10) and in later publications. The first hybrid to be produced and widely used was Double Crossed Burr-Leaming. Other double crosses, three-way crosses and top crosses were made at this time but this one combination was the most promising. This crossbred corn combined two inbred strains of Leaming with two inbred strains of Burr White. The latter variety had been selected in naturally pollinated field plantings at the Illinois Experiment Station for high and for low protein content. Consequently, it had been considerably inbred at the time it was first grown and self-fertilized in Connecticut by H. K. Hayes in 1914 or shortly before. These Burr White inbreds had no relation with the Burr White inbreds started by Davenport and Holden. One inbred came from the high protein line and one from the low. When crossed for the first time in 1915, these two lines showed a high level of vigor with valuable stalk and ear qualities.

This Burr White corn was quite distinct in type from the Leaming. It had stronger stalks, broader, greener leaves, with narrow cylindrical ears having 14 to 16 rows of grain. The kernels were white, nearly round in outline with a shallow indentation. The endosperm was hard and bright with a high proportion of corneous starch.

These Leaming and Burr White single crosses combined to produce a hybrid that was outstanding in yield of grain and vigorous stalk growth. In spite of the fact that the hybrid had a mixture of yellow and white kernels on each ear, it was grown on many farms from New England to Iowa from seed produced commercially first by George S. Carter at Clinton, Connecticut, in 1921 and later by other growers. In 1919 Henry A. Wallace in Iowa produced a small amount of Burr-Leaming seed by hand pollination of the two single crosses produced in Connecticut and in 1924 Marian T. Meyers produced seed of this double cross in Ohio in a crossing field.

Figure 2. The crossing field grown in 1947 for the production of Connecticut 830 and other experimental hybrids.

Burr-Leaming was too late in maturity to be grown for grain in the northern part of Connecticut. An earlier maturing hybrid was produced by combining inbred strains of Canada Yellow Flint as a seed parent with the same Leaming single cross used in the production of Burr-Leaming as the pollen parent. This hybrid, called Canada-Leaming, is described in Station Bulletin 310. This combination of flint and dent corn was grown for many years from Connecticut to northern New England and New York. It produced good yields of early maturing grain corn in the southern part of this region and was a high yielding ensilage variety in northern sections.

As soon as newer superior hybrids were produced, both Burr-Leaming and Canada-Leaming were replaced by them. Newer varieties stand up better, are more resistant to leaf blight and bacterial wilt, have better stalk characters and yield well under a wide range of soil and seasonal conditions. The original hybrids served their purpose, however, by showing what this new kind of corn could do.

THE INBREEDING PROGRAM IN CONNECTICUT

The first local varieties of corn to be selected in self-fertilized lines were Burwell's Canada Yellow Flint, Gold Nugget Flint, Century Dent, Stadtmueller's and Beardsley's Leaming. These inbreds are described in Bulletin 266 and the best of these were used in the production of Canada-Leaming and other experimental hybrids.

Following this inbreeding program, there was an extensive series of inbreds from Sanford White Flint, Sweepstakes Yellow Dent and Lancaster Surecrop. None of the Sanford White or Sweepstakes inbreds have been used but from Lancaster Surecrop three inbreds were produced which have been numbered and released for general use. These are listed and described below. Inbreds from other varieties and crosses of inbreds have been numbered and released. An extensive series of inbreds is now in process of selection. These will be numbered and released as soon as they have demonstrated their usefulness.

As soon as inbred strains were available from the midwest experiment stations, they were tested for their adaptation to Connecticut conditions. Many of these have proved outstanding and are now being used in the Connecticut numbered hybrids. In general, these are the inbreds which have been proved to be most useful in the main corn-growing regions in the north central states. A large series of inbreds is available for testing, ranging widely in stalk growth and maturity. In cooperation with the Northeastern Corn Conference, comprising 12 states from Delaware to Maine, the most promising of the old and new inbreds are now being grown in several different places where they appear to be best suited. The most promising combinations of these inbreds are being compared in regional trials during several seasons and on different soils of varying fertility levels.

Figure 3. The pollen parent single cross, Hy $\times$ C106, used in the production of Connecticut 843 and other experimental hybrids.

TESTING OF INBREDS

All-Combination Tests

All-combination tests are made by crossing a series of selected inbreds, usually 10, with each other. Ten inbreds can be put together in 45 different single crosses not counting reciprocal combinations, since for all practical purposes A × B is the same as B × A. The number of different single crossed combinations is calculated from the formula $\frac{1}{2}N(N-1)$ where N is the number of inbreds to be tested.

From the actual field results secured from these 45 single crosses, the performance of each of the 630 possible double crosses (A × B) × (C × D), etc., can be predicted quite accurately by averaging the actual results obtained for any measurable character from the four critical combinations, AC, AD, BC and BD. While it is useful to know the productiveness and other characters of the two non-critical combinations, AB and CD, their results do not enter into the predicted double cross.

The number of possible double crosses, excluding reciprocals in both of the single cross parents and in the final double cross, is calculated from the formula $\frac{1}{8}N(N-1)(N-2)(N-3)$ where N is again the number of inbreds involved. Since for all practical purposes A×B and B×A give the same results in the final double cross, all reciprocals are excluded. For example, if A×B and C×D are listed, B×A and D×C are omitted. Similarly (A×B)(C×D) is included but (C×D)(A×B) omitted. Table 1 gives the number of inbreds, number of different single crosses, three-way and double crosses, which can be made from these inbreds up to N = 11.

TABLE 1

THE NUMBER OF POSSIBLE COMBINATIONS OF TWO, THREE AND FOUR INBREDS, NOT INCLUDING RECIPROCALS, MADE FROM A GIVEN NUMBER OF INBREDS

Number of Inbreds	Crosses of Two Inbreds	Crosses of Three Inbreds	Crosses of Four Inbreds
1	0	0	0
2	1	0	0
3	3	3	0
4	6	12	3
5	10	30	15
6	15	60	45
7	21	105	105
8	28	168	210
9	36	252	378
10	45	360	630
11	55	495	990
N	$\frac{1}{2}N(N-1)$	$\frac{1}{2}N(N-1)(N-2)$	$\frac{1}{8}N(N-1)(N-2)(N-3)$

This method of estimating the yield and other characters of a double cross was outlined briefly by the senior writer in 1918 (10). Evidence confirming the close correlation between the predicted and actual results has been obtained by Jenkins (9), Doxtator and Johnson (4), Anderson (1), Eckhardt and Bryan (5) and Hayes, Murphy and Rinke (6). This method is

TABLE 2

ESTIMATED PERFORMANCE OF THE 46 HIGHEST YIELDING DOUBLE CROSSES AMONG THE 10 PARENTS OF THE SINGLE CROSSES OF U. S. 13 MATURITY. THE SINGLE CROSSES WERE GROWN IN CONNECTICUT, DELAWARE, MARYLAND, MISSOURI, NEW JERSEY, PENNSYLVANIA AND WEST VIRGINIA IN 1947. FROM THE REPORT OF THE COOPERATIVE UNIFORM COMPARISONS OF CORN HYBRIDS FOR 1947, COMPILED BY MERLE T. JENKINS, L. A. TATUM AND L. S. MAYER.

N. East Experimental Hyb. No.	Pedigree	Acre Yield (bu.)	Moisture in Grain (pct.)	Plants Erect at Harvest (pct.)	Plants Root Lodged (pct.)	Broken Plants (pct.)	Days to Silk (no.)
7801	(C102 × C103) × (Hy × B10)	85.1	22.8	79	9	27	71
7802	(C102 × C103) × (Wf9 × B10)	84.8	21.6	83	10	22	70
7803	(C102 ×C103) × (Wf9 × Hy)	84.6	21.7	83	14	22	68
7804	(Oh41 × C102) × (Hy × B10)	83.1	22.9	69	7	38	70
7805	(Oh7A × C102) × (Hy × C103)	82.5	22.9	83	11	25	72
7806	(C102 × C103) × (Oh7A × B10)	82.5	23.3	82	9	25	73
7807	(C102 × C103) × (38-11 × B10)	82.5	21.9	82	3	24	72
7808	(Wf9 × C102) × (Hy × C103)	82.3	21.7	83	12	23	69
7809	(Hy × B10) × (L317 × C102)	82.3	22.4	70	9	38	71
7810	(Oh7A × C102) × (38-11 × Hy)	82.3	22.2	80	7	27	71
7811	(C102 × C103) × (38-11 × Hy)	82.3	22.0	81	7	25	71
7812	(C102 × C103) × (Hy × Oh7A)	82.3	23.3	81	14	25	71
7813	(Oh7A × C102) × (Hy × B10)	82.3	22.5	75	8	31	71
7814	(C102 × C103) × (Wf9 × 38-11)	82.0	20.8	86	8	19	70
7815	(C102 × C103) × (Wf9 × Oh7A)	82.0	22.1	86	14	20	70
7816	(Oh41 × C103) × (Hy × B10)	81.5	25.1	77	3	33	72
7817	(Oh41 × C102) × (38-11 × Hy)	81.4	22.5	73	6	33	70
7818	(Oh7A × C103) × (Hy × C102)	81.4	22.7	83	8	24	72
7819	(Oh41 × C102) × (Wf9 × Hy)	81.4	21.9	74	12	32	68
7820	(Oh41 × C102) × (Hy × C103)	81.3	23.4	77	7	30	70
7821	(38-11 × Hy) × (L317 × C102)	81.3	21.7	73	7	36	71
7822	(Wf9 × Oh7A) × (Hy × C102)	81.0	21.3	82	11	24	69
7823	(Hy × Oh7A) × (L317 × C102)	81.0	22.9	75	15	33	71
7824	(B10 × C103) × (Wf9 × C102)	81.0	21.9	84	7	22	70
7825	(Oh7A × C102) × (Wf9 × Hy)	80.9	21.2	81	14	23	69
7826	(Wf9 × Oh7A) × (Hy × C103)	80.9	23.5	88	10	20	70
7827	(Wf9 × C102) × (Hy × B10)	80.8	21.7	78	10	27	69
7828	(Hy × B10) × (L317 × C103)	80.7	24.6	78	5	34	72
7829	(Oh7A × C103) × (Hy × B10)	80.7	24.7	83	4	26	73
7830	(B10 × C102) × (Wf9 ×C103)	80.6	22.1	85	7	23	71
7831	(Hy × C102) × (L317 × Oh41)	80.6	23.4	68	11	41	70
7832	(Hy × C103) × (L317 × C102)	80.5	23.0	77	9	32	71
7833	(Oh41 × C103) × (Wf9 × B10)	80.3	24.0	81	7	28	71
7834	(Wf9 × Hy) × (L317 × C102)	80.2	20.8	75	14	33	69
7835	(Oh41 × C103) × (Wf9 × Hy)	80.2	23.9	80	8	27	70
7836	(38-11 × Oh7A) × (Hy × C102)	80.1	22.1	80	6	26	72
7837	(Wf9 × C103) × (Hy × C102)	80.1	21.4	84	8	24	69
7838	(Oh7A × C102) × (Hy × Oh41)	79.9	23.2	74	11	34	71
7839	(C102 × C103) × (Oh41 × B10)	79.9	23.8	77	6	30	72
7840	(Oh7A × Oh41) × (Hy × C103)	79.8	25.2	82	5	27	72
7841	(Wf9 × C102) × (38-11 × C103)	79.7	21.6	85	6	21	70
7842	(Oh41 × C102) × (38-11 × B10)	79.7	22.0	73	2	34	72
7843	(Oh41 × C102) × (Wf9 × B10)	79.7	21.5	74	8	33	70
7844	(Oh7A × Oh41) × (Hy × C102)	79.7	23.5	74	9	34	71
7845	(Oh41 × B10) × (Hy × C103)	79.7	25.4	78	3	32	72
7846	(C102 × C103) × (38-11 × Oh7A)	79.7	22.4	84	8	22	72

now the standard procedure for obtaining the most useful combinations of the available inbreds, not only for yield, but for any character that can be measured.

In 1947 the all-combination test in the U. S. 13 maturity group included 10 inbreds. The 45 single crosses were tested in eight places. The 90 highest yielding double crosses predicted from the average performance of the single crosses include either C102 or C103 or both in all but two. Table 2 gives the predicted performance for 46 of the highest yielding double crosses. These predicted hybrids are not only high in yield but are also low in the number of lodged and broken plants, and are relatively free from leaf blight and stalk and ear rots. Both C102 and C103 were derived from Lancaster Surecrop after 10 generations or more of selection of individual plants and progenies. C103 has notable ability to stand erect until the end of the season, free from stalk breakage and leaf blight. This inbred is characterized by a stalk that has a large number of vascular bundles, heavy walled fibre cells and solid pith cells that have a high sugar content. C102 is less resistant to breakage but produces a larger stalk and ear and contributes fast growth and high yields of total dry matter and of grain to its hybrids.

A Restricted Combination Test

An all-combination test of inbreds frequently brings together related lines, or lines so similar in ancestry and in genetic characters as to be low in vigor and yield when crossed. Such lines would never be used in the production of a commercial hybrid unless both are used in the same parent, usually the pollen parent. For that reason it is largely a waste of time and effort to make all combinations of any selected list of inbreds. It would, therefore, be worthwhile to make a restricted combination test by first classifying the inbreds as potential seed parents or pollen parents and then making only the single crosses of each seed parent inbred with each of the several pollen parent inbreds. This requires an arbitrary separation of inbreds, with the danger of missing some combinations which might be quite valuable. However, long experience with inbreds usually indicates quite clearly whether they should be used for seed or pollen production. In many cases, no matter how good the final cross might be, it would be undersirable to make some combinations due to the fact that the single crosses are poor seed or pollen producers, or do not flower at the right time to be properly fertilized.

If 10 inbreds are separated into two groups of five each, one lot to be considered as potential seed parents, and the other potential pollen parents, then the possible single cross test combinations of seed parent by pollen parent inbreds are reduced to 25 instead of 45. From these two sets of five inbreds, 10 seed parent and 10 pollen parent single crosses are possible. These could be used to make 100 double crosses. There would be a considerable saving in the number of single crosses to be grown and this would make possible the testing of many more inbreds. It would be necessary to produce and compare the seed and pollen parent single crosses but this would involve only those combinations which were indicated to be outstanding by the restricted combination test. Undoubtedly, some good combinations would be missed but, since these combinations would be difficult to use in commercial seed production, this would be no great loss. In the all-combination tests as now conducted many good predicted hybrids are never made or tested because the inbreds are too difficult to use in that particular combination.

To illustrate the advantages of a restricted combination test of inbreds, let us take the 1947 all-combination test of late inbreds in the U. S. 13 maturity group grown at Mt. Carmel, Conn. The ten inbreds included in this test are: Connecticut 102, 103, Illinois Hy, Indiana Wf9, 38-11, Iowa B10, L317, Kansas 230, Ohio 07A, 41. Since four of these lines are derived from Lancaster Surecrop, they should not be used for test crosses with each other. Lancaster lines are usually better adapted as pollinators than as seed parents, and for the purpose of this comparison are so classified. While Hy can be used either as a seed-parent or pollen parent, it is generally used as a pollinator and will be included with the four Lancaster lines to make five pollinator inbreds. Wf9, 07A and 38-11 are widely used as seed parents. With

Figure 4. The test cross Wf9 × A158 used to determine the value of Connecticut 540 and other early grain corn hybrids. Note the sturdy stalks and low ear position.

these we can include B10 and K230. The ten inbreds are then classified as follows:

Seed Parents	Pollen Parents
Wf9	C102
07A	C103
38-11	Oh41
B10	L317
K230	Hy

These 10 inbreds make 25 single crosses in a restricted combination test to be used in predicting the performance of 100 double crosses. Of these 100 predicted double crosses, 67 were predicted to be above average in yield. Of the entire 630 predicted doubles from the all-combination, 332, or 53 per cent, were above the average. The comparison is, therefore, very much in favor of the restricted double crosses since 67 per cent instead of 53 per cent were above the average in yield. The 332 all-combination double crosses is a deviation of 17 from 315 expected on random distribution and is not significant since $X^2 = 1.84$ and $P = 10$—20 per cent. The 67 restricted double crosses is also a deviation of 17 from the expected 50 on random distribution but this deviation is highly significant since $X^2 = 10.56$ and $P < 1$ per cent.

While it is true that this restricted test predicts a much smaller number of double crosses, 100 compared to 630 in this case, the 100 contain a much higher proportion of the high yielding combinations. This information is obtained by producing and growing only 25 single crosses as compared to 45 for the all-combination test.

Not all lists of inbreds can be so easily classified as this one into desirable seed parents and pollen parents. For that reason, in making up a list of seed parent and pollen parent inbreds for a restricted combination test, it is important to have all available information on time of flowering, amount and kind of seed produced, particularly the susceptibility of the inbreds to ear and kernel rots, and their ability to produce pollen under unfavorable conditions. Twenty-five single crosses can be tested in a 5 x 5 lattice square much more easily than the 45 entries in an all-combination test of the same 10 inbreds.

INBREDS USED IN CONNECTICUT HYBRIDS

The most promising inbreds for Connecticut, selected after many years of growing and testing both as inbreds and in combinations, are listed below. The details of color and other characters are given for identification and determinations of trueness to type. Color characters are variable due to seasonal and environmental conditions.

Connecticut	C101, C102, C103, C104, C105, C106, C107
Illinois	A, M14, R1, R2, R3, R4, Hy
Indiana	Wf9, P8, 38-11
Iowa	B8, B9, I159, I205, L289, L317, Os420
Kansas	K4, Kys, K155
Minnesota	A158, B164
Missouri	G
Ohio	28, 40B, 41, 43, 51A, 56A
Wisconsin	W9, WM13, W22
U. S. Dept. of Agric.	CI7, CI Kr 187-2

Description of Inbreds

C101 LANCASTER SURECROP FROM EASTERN STATES FARMERS' EXCHANGE GROWN IN PENNSYLVANIA

Stalk:	Medium height, 14 nodes, medium width, erect
Tassel:	Medium size, compact, upright branches, no color in glumes, medium pollen production
Leaves:	Medium green, medium width, spreading and drooping, no stripes, flecks or dots, top leaves yellowish, no color in blade or sheath
Ear:	One, short, narrow, upright, short shank
Cob:	Slender, red
Kernel:	Round, smooth, shallow dent, soft cap, light yellow
Husk:	Short, tips of ears exposed
Roots:	Weak, plants frequently lodged
Disease:	Smut at ear node or below and in tassel
Insects:	Aphis in tassel

Contributes high yield and weak stalks to its hybrids; not used in any hybrid but may have value for reworking into another inbred.

C102 LANCASTER SURECROP FROM NOAH HERSHEY, PENNSYLVANIA

Stalk:	Tall, 15 nodes, long internodes, no color, thick but soft and weak in texture, bends and breaks easily
Tassel:	Small, few branches, erect, no color, poor pollen production
Leaves:	Medium to dark green, no stripes, flecks or dots, medium to wide, erect, no color in blade, lower sheaths reddish
Ear:	Mostly two-eared, long narrow well covered, upright, short shank, silks colored
Cob:	Slender, red
Kernel:	Small, round, smooth, shallow dent, lightly colored pericarp, medium yellow
Husk:	Green, long
Roots:	Weak, few brace roots, plants lodge frequently
Disease:	No smut, low blight infection
Insects:	No aphis

Contributes very high grain yield and good grain quality, and large stalk growth with high stalk breakage and lodging.

C103 LANCASTER SURECROP FROM NOAH HERSHEY, PENNSYLVANIA

Stalk:	Tall, slender with long internodes, no color; vascular bundles numerous with thick, solid cell walls; outer portion of culms woody; pith solid and high in sugar; outstanding for low breakage as an inbred and in hybrids
Tassel:	Branches long, upright, no color in glumes or anthers
Leaves:	Broad, stiff, upright, light green, dotted and flecked
Ear:	Long, cylindrical, slender, silks light red, medium height
Cob:	Small, red
Kernel:	Smooth, hard, dark yellow, pericarp tinged red, smooth shallow dent
Husk:	Long, tight, ears well covered
Roots:	Abundant with well developed brace roots, plants seldom lodged
Disease:	Remarkably free from stalk rot and leaf blight, no smut
Insects:	No aphis, highly resistant to corn borer damage

Contributes strong stalks with low breakage and low lodging, rapid maturity with some kernel rot in some combinations.

C104 LONGS CHAMPION

Stalk: Tall, thick, colored
Tassel: Small, few short branches, glumes red, anthers colored
Leaves: Broad, upright, light green, yellow and dead, sheaths red
Ear: Large, broad, short shank
Cob: Large, soft, light red
Kernel: Small, shallow, medium yellow, dull reddish pericarp
Husk: Long, loose, red
Roots: Well developed and well braced
Disease: Smut, cob and kernels frequently moldy, blight
Insects: Aphis on tassel and upper leaves

Contributes very large stalk growth and poor grain quality, slow drying.

C105 PURPLE FLOUR #626 × OHIO YELLOW DENT INBRED #25

Stalk: Short, 12 nodes, short internodes, thick, no color
Tassel: Large, many branches, erect, good pollen production, light glume color
Leaves: Medium green, no color on blade or sheath, medium width, spreading and drooping, light stripes and flecks
Ear: Medium size, short shank, erect
Cob: Soft, frequently moldy
Kernel: Round, soft, medium yellow, shallow dent
Husk: Long, ears well covered
Roots: Plants mostly erect and well braced
Disease: Much discoloration on sheaths and husks, no smut
Insects: No aphis

Contributes short stalk, low ear position and early maturity.

C106 LANCASTER SURECROP FROM IOWA LDG(K) × L317 SELFED AND SELECTED FOR LOWER STALK AND EAR

Stalk: Medium height, slender, 12 nodes, no color, red on brace roots
Tassel: Medium size, long branches, mostly erect, slight color on glumes, bright pink anthers, much pollen
Leaves: Medium width, erect, very dark green
Ear: One medium size, short shank, erect, bright pink silk color
Cob: Small, red
Kernel: Small, round, hard, bright, slight or no dent
Husk: Medium length, no color
Roots: Plants erect, well braced
Disease: Slight discoloration on sheaths, no smut
Insects: No aphis, breaks readily when infested with corn borer

Contributes high yeild, good grain quality, low lodging and medium stalk breakage.

C107 C1540, OH07, ILL701 INTERCROSSED AND SELFED. OH07A IS A RELATED LINE

Stalk: Tall, slender, no color, 13 nodes, strong
Tassel: Medium size, branches horizontal, no color in glumes or anthers, much pollen
Leaves: Medium to light green, prominent white lines, medium to narrow, erect
Ear: Two, small, short shank, erect, silks green
Cob: Small, red
Kernel: Deep, bright yellow, smooth shallow dent
Husk: Long, no color
Roots: Plants well braced and erect
Disease: No smut, discoloration on sheaths
Insects: Aphis on upper leaves and tassels

Contributes high yield, high shelling percentage and good grain quality.

ILLINOIS A (J. R. HOLBERT U.S.D.A.) FUNK YELLOW DENT, RELATED TO R4, OH28, A375

Stalk:	Medium width and height, strong
Tassel:	Large, branches erect, no color in glumes or anthers
Leaves:	Light green, tendency to turn yellow and red and to dry prematurely
Ear:	Broad, medium length, well filled, silks uncolored
Kernel:	Medium sized, deep, smooth dent, bright, well matured
Husk:	Ears usually well covered
Roots:	Well developed, strong, plants seldom lodge
Disease:	Susceptible to leaf blight and stalk rots
Insects:	Much breakage from corn borer

Contributes tall stalks, rapid drying, good grain quality to many hybrids. One of the most useful inbreds in the Northeast. Combines well with many inbreds, especially Hy.

ILLINOIS M14 ILLINOIS EXPERIMENT STATION, ORIGINALLY FROM B. E. MOEWS, GRANVILLE, ILL. SINGLE CROSS BR 10 × R8

Stalk:	Short, stiff stalks
Leaves:	Dark green with pronounced lighter green stripes
Ear:	Low
Cob:	Large, red
Kernel:	Round, smooth, bright yellow, shallow dent
Husk:	Short, poor coverage
Roots:	Weak, plants frequently lodge
Disease:	Leaf blight
Insects:	Heavy aphis infestation

Contributes length of ear, good grain quality and early maturity. Combines well with Wf9, 187-2, 90, Hy, R4. Not satisfactory on account of lodging.

ILL. R1

Stalk:	Medium height, 15 nodes, thick, no color
Tassel:	Large, many branches, erect, no color, much pollen
Leaves:	Medium green, wide, erect, flecked yellow and dead at tips of upper leaves no color in blades or sheaths
Ear:	Two, long, silks uncolored
Cob:	Medium size, red
Kernel:	Round and wedge shaped, hard, smooth shallow dent, bright yellow
Husk:	Long, ears well covered, no color
Roots:	Erect, well braced
Disease:	Smut at ear node or below
Insects:	Aphis on tassel and upper leaves

ILL. R2 REID YELLOW DENT × KRUG YELLOW DENT

Stalk:	Medium to tall, medium width
Tassel:	Few erect branches, glumes dark red
Leaves:	Medium dark green, slightly crinkled, flecked, sometimes striped
Ear:	Mostly two, long, slender, cylindrical, 16 rows, bright red silks
Cob:	Bright red
Kernel:	Round, smooth, shallow dent, bright yellow, easily shelled
Roots:	Plants mostly erect, well braced
Disease:	Smut on bottom nodes, some leaf blight
Insects:	No aphis, much breakage with corn borer infestation

Contributes ear length, good grain quality, rapid drying, earliness and yield.

ILL. R3 WISCONSIN R3 (CC1) REID YELLOW DENT

Stalk:	Medium height, no color
Tassel:	Small, branches erect, glumes colored
Leaves:	Medium green, medium width, no color
Ear:	Medium size, often poorly filled, silks green
Cob:	Medium size, dark red
Kernel:	Small, round and wedge shaped, hard, smooth, shallow dent, bright yellow
Husk:	Long, ears well covered, no color
Roots:	Well developed, plants seldom lodged
Disease:	No smut, very little leaf blight
Insects:	Aphis on tassels and leaves, much breakage with corn borer infestation.

ILL. R4 FUNK YELLOW DENT

Stalk:	Medium to tall, wide, soft
Tassel:	Medium size with many branches, glumes colored, glume base colored, anthers colored
Leaves:	Wide, dark green, crinkled, many red and dead leaves before maturity
Ear:	Large, tapering
Cob:	Large, dark red
Kernel:	Small, wedge shaped, deep, rough dent, dull yellow, soft
Husk:	Long, ears well covered
Roots:	Weak, plants lodge badly at all stages
Disease:	No smut, much blight
Insects:	No aphis, resistant to first brood of corn borer but susceptible to second brood, stalks break easily

Contributes drought resistance and high yield under varying levels of soil fertility.

ILL. HY ILLINOIS HIGH YIELD SELECTION OF LEAMING DEVELOPED BY A. M. BRUNSON AT THE KANSAS AGRICULTURAL EXPERIMENT STATION AND FURTHER SELECTED AND RELEASED BY J. R. HOLBERT AT THE ILLINOIS AGRICULTURAL EXPERIMENT STATION

Stalk:	Variable in height, usually tall, medium width, strong
Tassel:	Variable in size, branches erect and often aborted at tips, glumes variably colored from light to dark, anthers colored or colorless, abundant pollen production
Leaves:	Short, stiff, upright, light, yellowish green, sheaths colored
Ear:	Small, tapering, silks light red or colorless, ear height variable
Cob:	Soft, light red
Kernel:	Smooth, round, slight dent, usually with soft light cap, variable in color and texture
Husk:	Long, colored, small streamers
Roots:	Well developed, well braced, most resistant to lodging
Disease:	Some smut on ears and stalks and many strains show heavy leaf blight infection, sheaths usually discolored, cobs rot easily
Insects:	Some aphis on tassel and leaves, much breakage when infested with corn borers

Contributes strong, tall stalks, low lodging, wide adaptability to different levels of soil fertility, short ears, slow drying. Combines well with many inbreds of widely different type.

IND. WF9 (R. R. ST. JOHN) REID YELLOW DENT (WILSON FARM ROW 9)

Stalk: Medium height and width, slight tendency to break
Tassel: Medium size, produces small amount of pollen under most favorable conditions and may be completely pollen sterile under poor conditions
Leaves: Broad leaves, dark green
Ear: Cylindrical, compact, well filled, tips bare, silks green
Kernel: Rough, dull, dark yellow
Husk: Compact, tips well covered
Roots: Slight tendency to lodge
Disease: Susceptible to leaf blight, very little smut and ear rot
Insects: Moderate aphis on tassel and upper leaves

Contributes large, vigorous seedling growth, strong stalks, well shaped ears, grain quality, high yield and early maturity. One of the most widely used inbreds throughout the country. Most useful in the seed parent.

IND. P8 PALIN DENT OUT OF REID YELLOW DENT

Stalk: Medium height, medium width, 16 nodes, strong, little breakage, no color
Tassel: Large, many branches, erect, much pollen, no color in glumes or anthers
Leaves: Dark green, dotted, creased, wide, erect, no color in blade or sheath
Ear: One, short shank, short, wide, green silks
Cob: Flattened at tip, sometimes fasciated, red
Kernel: Small, wedge shaped, hard, medium yellow, deep, smooth dent
Husk: Long, ears well covered, no color
Roots: Plants well braced and erect
Disease: Smut below ear, discoloration on sheaths, leaves yellow and dead at tips, smut, many aphis on tassel

Contributes strong stalks and good grain quality.

IND. 38-11 (R. R. ST. JOHN) REID YELLOW DENT (PROBABLY OUTCROSS IN LINE FROM FUNK 176A)

Stalk: Stiff, strong but brittle, ears drop
Leaves: Dark green, dotted late in season
Ear: Long, large, cylindrical
Cob: Slender, red
Kernel: Small, round, deep smooth dent, purple plumule, dark yellow
Husk: Short
Roots: Excellent, probably as good as any inbred
Disease: Smut on ears
Insects: Much breakage from corn borer

Contributes large stalk growth, strong roots, ability to withstand heat and drought, chinch bugs and corn root worm, needs high fertility to produce well.

IOWA I159

Stalk: Tall, slender, brittle, breaks easily at nodes, 15 nodes, internodes colored, many tillers
Tassel: Small, few branches, short, spreading, small amount of pollen, red glumes, anthers
Leaves: Dark green, erect, medium width, reddish on sheaths and margins of blade, no dots, flecks or stripes
Ear: One and two, slender, short shank, erect, green silks
Husk: Long
Cob: Slender, dark red
Kernel: Large, flat, mostly round, hard, bright, dark yellow
Roots: Plants well braced and erect
Disease: Smut on tillers, discoloration on sheaths, leaf blight
Insects: Aphis on tassel, much stalk breakage with corn borer infestation

Contributes good grain quality and rapid drying.

IOWA I205 IOWA EXPERIMENT STATION

Stalk:	Medium height, slender, strong
Tassel:	Medium size, branches mostly upright, glumes light red and glume base colored, anthers colored, much pollen
Leaves:	Light green, sheaths red
Ear:	Two, short, broad
Cob:	Small, bright red
Kernel:	Wide, deep, large smooth dent, soft, light yellow, slow drying, lowest in carotene
Husk:	Long
Roots:	Well developed and well braced, plants seldom lodge
Disease:	Embryos susceptible to mold infection, blight on lower leaves
Insects:	Some aphis on tassels and upper leaves

Contributes high yield, wide adaptability, strong stalk, and good pollen production with heat and drought.

IOWA L289 LANCASTER SURECROP (IOWA EXPERIMENT STATION)

Stalk:	Tall, slender
Tassel:	Large, spreading, glumes and anthers colored
Leaves:	Wide, medium green, flecked, tendency to dry prematurely, top leaves blasted in hot dry weather
Ear:	Long, cylindrical, silks uncolored
Cob:	Slender, red
Kernel:	Broad, deep, smooth dent, dark yellow, good grain quality
Husk:	Medium long, loose
Roots:	Poorly developed and plants usually lodged badly
Disease:	Resistant to leaf blight, some smut
Insects:	Stalks break badly when infested with corn borer

Contributes high yield and good grain quality.

IOWA L317 LANCASTER SURECROP. RELATED TO LDG (M. T. JENKINS)

Stalk:	Slender and tall
Tassel:	Medium size, red anthers
Leaves:	Very dark green, excellent
Ear:	Long, tapering at both ends, silks uncolored
Cob:	Small, red
Kernel:	Dull yellow, small, round, smooth, shallow dent
Husk:	Long, coverage good
Roots:	Plants erect
Disease:	Leaves dry prematurely, kernels split and frequently rotted
Insects:	Much breakage from corn borer

Contributes high yeild, tall stalks; ear and kernel rots; slow seedling growth.

IOWA OS420 OSTERLAND YELLOW DENT FROM REID DENT, IOWA EXPERIMENT STATION

Stalk:	Medium height, wide, soft
Tassel:	Medium to large, good pollen production
Leaves:	Light, easily shredded
Ear:	Short, broad
Cob:	Large, dark red
Kernel:	Large, soft, rough, reddish, deep dent
Husk:	Medium long
Roots:	Well developed and well braced, plants seldom lodge
Disease:	Shows much stalk and ear rot, leaf blight
Insects:	Much breakage from corn borer, heavy aphis infestation

Contributes high yield and ability to withstand heat and drought, slow drying.

KANSAS KYS KANSAS YELLOW SELECTION NO. 1 (R. W. JUGENHEIMER, MANHATTAN, KANSAS)

Stalk: Medium thickness and height, internodes colored
Tassel: Small, thick branches, glumes lightly colored, anthers colored
Leaves: Light yellowish green, flecked, lower sheaths reddish
Ear: Medium size, silks uncolored
Cob: Small, white
Kernel: Small, bright orange yellow
Husk: Medium length, ear well covered
Roots: Well developed, plants seldom lodged

Contributes good stalk and root quality.

KANSAS K4 KANSAS YELLOW SUNFLOWER

Stalk: Tall, slender, strong
Tassel: Medium size
Leaves: Dark green, lower leaves dry prematurely
Ear: Two, small, cylindrical
Cob: Small, red
Kernel: Bright yellow, medium size, smooth dent
Husk: Long
Roots: Plants sometimes lodge from root weakness
Disease: Resistant to leaf blight

Contributes high yield in some combinations, withstands heat and drought, but too late for best maturity at Mt. Carmel.

K155 YELLOW SELECTION FROM PRIDE OF SALINE

Stalk: Tall, medium width, bent above ear
Tassel: Small, compact, many branches, erect, enclosed in leaves, no color in glumes or anthers
Leaves: Light green, light and dark stripes, flecked
Ear: Long, slender
Cob: Small, white
Kernel: Large, round, hard, bright yellow, smooth, shallow dent
Husk: Long, ears well covered
Roots: Weak, plants sometimes lodged and bowed early in season
Insects: Breaks easily when infested with corn borer

Contributes large stalk growth and ability to withstand heat and drought.

A158 MINNESOTA 13, (A11 × A47)

Stalk: Medium height, 10 nodes, no color, medium width, very little breakage
Tassel: Large, 6 to 8 branches, long, horizontal, glumes light color, anthers colored, good pollen production
Leaves: Medium to dark green, no dots, flecks or stripes, medium width, drooping, no color, top leaves sometimes yellow or dead, light discoloration on sheaths
Ear: One, short, broad, short shank, ear at 45° angle
Cob: Slender, red
Kernel: Medium size, round or wedge shaped, hard, bright, dark yellow, smooth shallow dent
Roots: Plants well braced and mostly erect
Disease: No smut, some blight
Insects: Aphis on tassels and upper leaves but seldom persist and do not interfere with pollen production

Contributes strong stalks, low lodging, early maturity and good grain quality.

MINN. B164 REIDS YELLOW DENT. INBRED PRODUCED BY H. A. WALLACE AND R. BAKER

Stalk: Tall, 13 nodes, medium width, slight color, erect, very little breakage, bent at last and next to last nodes
Tassel: Large, medium number branches, long, glumes reddish, anthers colored, good pollen production
Leaves: Medium green, wide, reddish, erect and drooping, some color on sheaths and slight color on blades
Ear: Two, long, slender, short shank, erect, no color in silks
Cob: Medium size, red
Kernel: Long, irregular in shape, hard, medium yellow, smooth deep dent
Husk: Long, short streamers, ears well covered
Roots: Erect, well braced
Disease: Much discoloration on sheaths, some smut
Insects: No aphis

Contributes high yield.

MISSOURI G MISSOURI AGRICULTURAL EXPERIMENT STATION

Stalk: Short, medium broad, strong, no tillers
Tassel: Large, many branches, horizontal or upright, spreading, glumes light red, anthers light red
Leaves: Broad, dark green
Ear: Medium height, mostly two, silks green
Cob: Red
Kernel: Reddish yellow, medium size, slight or no dent
Husk: Short streamers
Roots: Large brace roots, dark red
Disease: Resistant to leaf blight

OHIO 28 CONNECTICUT LEAMING (BEARDSLEY) INBRED 112-1 × OHIO Y.D. (C112-1 × OH C920) (ILL.A × ILL.B)

Stalk: Medium height, 14 nodes, wide, no color, very little breakage but stalks often bent above ear after mature
Tassel: Medium size, glume base color, slight color in glumes, good pollen production
Ear: One and two, medium length and width, medium shank, erect, green silks
Cob: Small, glumes stiff, red
Kernel: Small, irregularly wedge-shaped, dark yellow, large smooth dent
Husk: Long, narrow streamers, some color
Roots: Plants well braced and erect
Disease: Slight discoloration on sheaths, no smut or blight, resistant to *H. Turcicum* and bacterial leaf blight
Insects: Few aphis on tassel

Contributes high yield, long shanks, rough, soft grain, early maturity, blight resistance and erect stalks.

OHIO 40B LANCASTER SURECROP RELATED TO CI 4-8 (OHIO EXPERIMENT STATION)

Stalk: Medium height, strong
Tassel: Large, long upright branches, abundant pollen, no color in glumes or anthers
Leaves: Dark green
Ear: Long, low on stalk, short shank, green silks
Cob: Soft, white
Kernel: Broad, shallow, dark yellow, soft, slow drying
Husk: Coverage good
Roots: Strong
Disease: Susceptible to stalk and ear rots, smut
Insects: Much breakage from corn borer, resistant to aphis

Contributes high yield, low ears, slow drying, short shank. Ear shoots should not be cut back as silks will not grow out. Highest yield in all-combination test.

OHIO 41 LANCASTER SURECROP. SELECTED FROM OHIO 40

Stalk:	Medium height, 15 nodes, thick, strong, reddish on basal internodes and brace roots
Tassel:	Sparse, reddish glumes, no anther color
Leaves:	Wide, dark green, erect, no color
Ear:	Two, long, slender, short shank, erect, no silk color
Cob:	Medium size, red
Kernel:	Medium size, round flat, hard, bright, dark yellow, smooth shallow or no dent
Husk:	Long
Roots:	Well braced
Disease:	Discoloration on sheaths, no smut, some blight, streaked dwarf plants
Insects:	No aphis

OHIO 43 LANCASTER SURECROP. SELECTED FROM OHIO 40

Stalk:	Medium height, 14 nodes, medium width, strong, no color
Tassel:	Large, branches long erect, no glume color, no anther color
Leaves:	Wide, erect, light green, top leaves yellow and dead, no color, light stripes
Ear:	Two, long, wide, short shank, erect, green silks, low on stalk
Cob:	Medium size, white
Kernel:	Large, mostly round, hard, bright dark yellow, smooth shallow or no dent
Husk:	Medium to long
Disease:	Slight discoloration on sheath, no smut, no blight
Insects:	No aphis

OHIO 51A (OH51 × OH17) OH51 OH51 FROM CLARAGE YELLOW DENT

Stalk:	Slender, medium height, strong, no color
Tassel:	Medium size, few upright branches, light color in glumes
Leaves:	Medium width, light green
Ear:	Mostly two, small, irregular and tapering, short shank, silks light red
Cob:	Small
Kernel:	Round, smooth, hard, irregular, shallow dent
Husk:	Short, tips of ears exposed
Roots:	Well developed, plants seldom lodged
Disease:	Resistant to leaf blight, stalk rot, some smut on ears
Insects:	No aphis, low breakage with corn borer infestation

Contributes strong stalks, low breakage, low lodging, early maturity. Poor ear shape.

OHIO 56A WOOSTER STRAIN OF CLARAGE

Stalk:	Short, 15 nodes, thick, strong, no color, tillers
Tassel:	Large, thick, no glume color, no anther color
Leaves:	Medium width, dark green, slightly erect and drooping, no color, prominent white lines
Ear:	Two, medium length, medium long shank, ears set at 45° angle, silks uncolored
Cob:	Medium size, red
Kernel:	Small, round and wedge shaped, hard, bright, dark yellow, deep, smooth dent
Husk:	Short, tips exposed
Roots:	Plants well braced, erect
Disease:	Smut on tillers, blight on lower leaves
Insects:	No aphis

W9 (CC4) GOLDEN GLOW

Stalk:	Medium to short, 10 nodes, slender, zigzag, strong, no color
Tassel:	Small, few branches, upright, glumes colored
Leaves:	Medium width, drooping, light and dark bands, medium green, no color on sheath or blade, flecked
Ear:	One, short, wide, short shank, erect, colored
Cob:	Large, red
Kernel:	Large, flat, oblong, hard, dark yellow, deep, rough dent
Husk:	Short, light red
Roots:	No brace roots above ground
Disease:	No smut, slight discoloration on sheaths
Insects:	No aphis

Contributes early maturity, good grain quality and high yield.

W M13 (CC8) SAME AS MINNESOTA A11 INBRED FROM MINNESOTA 13 VARIETY

Stalk:	Medium height, 9 nodes, slender, bent above ear at slight angle, slight color on internodes
Tassel:	Large, few long branches, spreading and curled at tips
Leaves:	Medium width, dark green, heavily flecked, no color
Ear:	Short, wide, low on stalk
Cob:	Large, dark red
Kernel:	Large, flat, oval, soft, dull yellow, smooth, shallow dent
Husk:	Long, slight color
Roots:	Few brace roots
Disease:	Smut on ear and nodes below ear
Insects:	No aphis

Contributes high yield and good grain quality.

W22 FROM ILL. B10 × W25 SECOND CYCLE

Stalk:	Medium height, thick, light red, pith solid and high in sugar
Tassel:	Medium size, branches short, erect, glumes colored, glume base colored
Leaves:	Wide, medium dark green, flecked, upper leaves yellow and dead
Ear:	Mostly two, medium size, long shank, medium height, silks green
Cob:	Small, red
Kernel:	Deep, rough, medium to dark yellow
Husk:	Long, light red
Roots:	Well developed and braced, plants seldom lodged
Disease:	Resistant to stalk rot, some smut and leaf blight
Insects:	Stalks break under corn borer infestation, no aphis

Contributes medium maturity and good grain quality. Good seed and pollen parent but susceptible to pollen blasting in hot, dry weather.

CI KR 187-2 KRUG

Stalk:	Medium height, 15 nodes, strong medium width, slightly zigzag, no color
Tassel:	Large, branches erect, much pollen, no color in glumes or anthers
Leaves:	Wide, erect, dark green, light and dark bands, no color
Ear:	One, long, set out at angle, medium long shank, medium height
Cob:	Medium size, red
Kernel:	Small, irregular in shape, dark yellow, smooth, deep dent
Husk:	Long
Roots:	Well braced, seldom lodge
Disease:	Smut on tassel and upper leaves, susceptible to blight, no discoloration
Insects:	Some aphis

Contributes high yield in warm, dry seasons; not adapted to cool climates.

CI 7 JOHNSON COUNTY WHITE. YELLOW SELECTION FROM INDIANA 33-16

Stalk:	Tall, strong, medium width, reddish on lower nodes
Tassel:	Large, spreading, no color on anthers or glumes, much pollen
Leaves:	Wide, dark green, red on sheaths
Ear:	One, medium size, short shank, erect, green silks, high on stalk
Cob:	Medium size, white
Kernel:	Large, flat, hard bright, light yellow, deep rough dent
Husk:	Medium long
Roots:	Plants well braced
Disease:	No smut, susceptible to blight, discoloration on sheaths
Insects:	Aphis on tassel and upper leaves

CONNECTICUT AS A CORN-GROWING REGION

According to Huntington, Williams and Valkenburg in their "Economic and Social Geography", Connecticut is entirely within the region of highest average corn yields in the North American continent. This region comprises southern New England, southeastern New York and Long Island, eastern Pennsylvania and northern New Jersey. In this area the average yields of grain corn for the 20-year period, 1910-1929, are 40 bushels per acre or above. Many of the western states exceed this average in good crop years but fall considerably below in the unfavorable seasons.

Connecticut's high yields are due largely to abundant rainfall and high humidity throughout nearly all of the growing season. Other factors are also involved but the absence of extreme high temperatures and long periods of low humidity and rainfall are the most important. While the average mean temperature is lower than in the main corn-producing regions, the growing season is usually long enough to mature the highest yielding varieties. Since most of the corn grown is used for ensilage, full maturity is not so important here as in the grain-growing areas.

Within the State, growing conditions vary widely due to the length of the frost-free period and to soil conditions. The longest growing period, 190 days free from frost, is found in a narrow strip along the Sound from the Housatonic River to the Rhode Island line. The shortest period, 140 days, is in the towns of Griswold, Voluntown and Sterling in the east central part of the State, and also in the extreme northwestern corner of the State in the towns of Salisbury, North Canaan, Canaan and Norfolk. The other parts of the State vary within these limits. All of the Connecticut River Valley and adjacent regions have a growing season of 170 days or more. The Valley soils are usually lighter in texture and are better drained than the upland soils. In the western part of the State these upland ridges have a tight subsoil that holds moisture and delays planting in the spring. Early maturing varieties are needed on these soils. On the other hand, Valley soils may be in frost pockets where the plants are killed late in the spring and early in the fall and these locations also require early maturity.

Corn Maturity Groups In Connecticut

Most of the varieties grown in Connecticut range in maturity from Cornell 29-3 and Ohio M15 as the earliest varieties, to U. S. 13 as the latest. When planted before June first, the early varieties are usually mature enough by September 15 to escape serious injury by frost. The late varieties in the U. S. 13 season usually mature for grain in the southern part of the State by October 15. However, they cannot be depended upon to mature satisfactorily every year. Varieties of this type give the highest yields of ensilage and are widely grown in all parts of the State for this purpose.

Where damage from corn borers and early fall storms is severe, it is highly desirable to complete corn harvesting by September 20. Early harvest also permits the planting of cover crops to prevent soil erosion during the winter and to add organic matter. For these reasons it may be advantageous to sacrifice something in yield by growing early maturing varieties.

Fortunately, there are available many varieties of corn that are early in maturity and as high in yield of grain as varieties that mature several weeks

Figure 5. A field of Connecticut 520 in mid August.

later. These are short stalked and will not give the ensilage yields that the later and larger growing varieties produce.

Where corn is grown for grain, the ears are usually harvested by machine and the stalks returned to the soil. This practice adds organic matter to the soil and is an important factor in promoting high yields. Where the stalks are used for forage or ensilage, it is necessary to return an equivalent amount of organic matter in the form of manure or cover crops to maintain soil fertility.

CONNECTICUT HYBRIDS

Numbering System

Corn maturity zones in the North American continent are divided arbitrarily by the northeastern corn conference into 10 groups and varieties in these groups are numbered in a series of 100, 200, 300, etc., up to 1,000, based on the length of growing season required to mature properly. This system of numbering does not conform to the numbers used in other regions. Most of the varieties grown in Connecticut fall in the series from 500 to 800. Varieties in the 500 series are similar in maturity to Pride of the North, Cor-

nell 29-3, Ohio M15, M20, M34 and Minnesota 404 and 405. Usually, these varieties, when grown in southern Connecticut, flower in 75 to 85 days after being planted about the middle of May, and have from 20 to 30 per cent of moisture in the grain when harvested the latter part of October.

The 600 and 700 series are represented by varieties of intermediate maturity such as West Branch Sweepstakes, Ohio K24, K35, M36, Wisconsin 464 and Iowa 939 and 4059. These maturity groups are not very clearly defined but usually require from 5 to 10 days longer to flower and have from 5 to 10 per cent more moisture in the grain when harvested. These maturity groups are well adapted to Connecticut. Higher yielding varieties with good stalk and ear qualities are needed in these seasons.

The 800 series comprise varieties such as Lancaster Surecrop. U. S. 13, Ohio C12, C92, W10 and the Connecticut sweet-dent hybrids. These are primarily ensilage types. On good soil they grow from 10 to 12 feet in height and produce large yields of total dry matter. They usually flower in 85 to 95 days after planting if the seed is sown before June 1 and reach the hard dough stage early in October. They cannot be counted on to mature satisfactorily for grain every year even in the areas having the longest growing season. In frost-free localities of southern Connecticut, they mature satisfactorily for grain about two years out of three.

Numbered Hybrids

The following numbered varieties have either been tested in Connecticut for several years or the single crosses have been grown long enough so that the predicted performance of these combinations is indicated to be good. Many of them have been grown in regional trials outside of Connecticut and some are in commercial production.

CONNECTICUT NUMBERED HYBRIDS IN THE OHIO M15 SEASON

510	(MS13×A) A158
520	(A×M14) A158
521	(A×M14) (A158×I205)
522	(A×M14) (A158×R2)
523	(A×M14) (A158×Oh51A)
530	(W9×A) (Wf9×Oh28)
531	(W9×A) A158
532	(W9×MS13) A158
540	(A×A158) (Wf9×W22)
541	(A×A158) (Wf9×Oh28)
542	(A×A158) (Wf9×Oh51A)
543	(A×A158) (Wf9×I205)
544	(A×A158) (Wf9×R2)
550	(W22×A) (Oh51A×B9)
551	(W22×Oh51A) A158
552	(Wf9×Oh51A) A158
553	(Wf9×W22) (A158×I205)
554	(Wf9×W22) (A158×Oh51A)
555	(Wf9×W22) A158
556	(Wf9×W22) (A158×R2)
557	(Wf9×A158) (A×I205)
558	(Wf9×I205) (W22×Oh51A)
560	(Wf9×A158) A
561	(Oh51A×A) A158
562	(Oh51A×M14) A158
563	(Oh51A×Oh28) A158

CONNECTICUT NUMBERED HYBRIDS IN THE IOWA 4059 SEASON

701	(R2×W22) (Hy×Oh51A)
702	(Hy×Oh51A) (I205×W22)
705	(Hy×W22) (I205×R2
709	(Hy×Oh51A) (I205×R2)
714	(Hy×W22) (I205×Oh51A)
716	(Oh51A×W22) (I205×R2)
722	(Oh51A×R2) (Hy×W22)
728	(R2×W22) (Hy×I205)
729	(Oh51A×W22) (Hy×I205)
734	(Oh51A×W22) (Hy×R2)
742	(R2×W22) (I205×Oh51A)

CONNECTICUT NUMBERED HYBRIDS IN THE U. S. 13 SEASON

803 (Wf9×Hy) (C102×C103)
805 (Oh7A×C102) (Hy×C103)
808 (Wf9×C102) (Hy×C103)
810 (Oh7A×C102) (38-11×Hy)
811 (C102×C103) (38-11×Hy)
812 (C102×C103) (Hy×Oh7A)
814 (Wf9×38-11) (C102×C103)
815 (Wf9×Oh7A) (C102×C103)
817 (Oh41×C102) (Hy×38-11)
818 (Oh7A×C103) (Hy×C102)
819 (Wf9×Hy) (Oh41×C102)
820 (Oh41×C102) (Hy×C103)
821 (Hy×38-11) (C106×C102)
822 (Wf9×Oh7A) (Hy×C102)
823 (Hy×Oh7A) (C106×C102)
825 (Wf9×Hy) (Oh7A×C102)
826 (Wf9×Oh7A) (Hy×C103)

830 (Wf9×P8) (Oh40B×I159)
831 (Wf9×P8) (Hy×C103)
832 (Wf9×P8) (C106×C103)
833 (Wf9×P8) (C102×C103)
834 (Wf9×P8) (I159×C103)
835 (Wf9×P8) (C102×CI7)
836 (Wf9×P8) (C103×CI7)
837 (Wf9×P8) (C102×38-11)
838 (Wf9×P8) (K155×C103)

840 (Wf9×P8) (Oh40B×C106)
841 (Wf9×W22) (Hy×C103)
842 (Wf9×W22) (Oh40B×C103)
843 (W24×B164) (Hy×C106)
844 (R4×G) (CI7×C103)
845 (P8×G) (CI7×C103)
850 (Wf9×B164) (Oh40B×C103)

860 (Wf9×P8) (Oh40B×C103)
870 (Wf9×38-11) (Hy×C103)
871 (Wf9×38-11) (C106×C103)
872 (Wf9×38-11) (Oh40B×C103)
873 (Wf9×38-11) (Hy×C106)

TABLE 3

SUMMARY OF THE NORTHEASTERN REGIONAL TRIALS IN 1947 CARRIED OUT IN SIX LOCATIONS IN CONNECTICUT, DELAWARE, MARYLAND, MASSACHUSETTS, NEW JERSEY AND PENNSYLVANIA

Pedigree	Yield in Terms of Rank	Per Cent Moisture	Per Cent Broken	Per Cent Lodged
Pioneer 300	1.030	24	30	3
Conn. 830	.948	25	26	2
Pioneer 332	.813	24	39	1
Conn. 860	.810	26	22	4
Funk G94	.698	25	32	0
Conn. 840	.523	23	28	0
Funk G169	.520	24	41	0
Pfister 173	.505	24	41	1
U. S. 13	.438	24	36	0
Crow 805	.220	23	32	1
Ohio C12	.125	22	31	0
Ohio W10	.060	23	40	2
Pioneer 336	–.097	25	39	0
(Wf9×P8) (CI 7×C103)	–.190	25	16	0
Iowa 4059	–.193	23	37	0
Field's 66I	–.327	23	37	1
Reid 126T	–.337	24	37	1
DeKalb 875	–.383	26	33	0
Field's 129L	–.437	23	38	0
Crow 608	–.485	25	38	0
Pfister 170	–.490	24	38	2
Reid 126R	–.712	23	35	1
DeKalb 847	–.867	25	34	0
Funk G80	–1.073	28	39	1
Ohio C92	–1.098	24	28	0

Significant difference at the 5 per cent level shown by dotted line.

TABLE 4

SUMMARY OF THE NORTHEASTERN REGIONAL TRIALS FOR THREE YEARS 1945, 1946, AND 1947

Pedigree	Av. Yield by Rank	Per Cent Moisture	Per Cent Broken	Per Cent Lodged	Sum of Deviation from Varietal Mean
Conn. 830	1.42	28	16	9	0
Conn. 840	.62	28	18	10	.93
U. S. 13	.26	28	24	6	.83
Ohio C12	.05	27	20	9	1.04
Ohio W10	–.05	27	24	9	.40
Ohio C92	–.33	28	16	9	3.36
Pioneer 336	–.79	28	26	11	1.27
Funk G80	–.85	30	22	9	0

Significant difference at the 5 per cent level shown by dotted line.

TABLE 5

COMBINED RATINGS OF ENTRIES IN EARLY GRAIN TRIALS OVER THE THREE YEAR PERIOD 1945 TO 1947

Entry	Rank[1]	Yield[2]	Per Cent Moisture	Days to Silking	Per Cent Broken	Per Cent Lodged
Conn. 530	1.18	132	29	72	10	1
Conn. 520	.93	133	26	72	4	1
Minn. 405	.73	130	28	70	13	0
Ohio M20	.33	127	27	73	13	1
Ohio M15	–.10	118	28	72	8	1
Minn. 500	–.62	111	25	70	13	0
Cornell 29-3	–.67	100	24	70	16	3
Mass. 62	–2.20	100	27	66	25	0
Minn. 604	–3.27	93	24	70	19	1

[1] Significant difference at the 5 per cent level shown by dotted line.
[2] Calculated as bushels per acre with 15.5 per cent moisture in the grain.

TABLE 6

COMBINED RATINGS OF ENTRIES IN EARLY GRAIN TRIALS OVER THE THREE YEAR PERIOD 1946 TO 1948

Entry	Rank[1]	Per Cent Moisture	Days to Silking	Per Cent Broken	Per Cent Lodged
Conn. 530	0.90	25	71	12	2
Conn. 520	0.62	24	75	3	1
Funk G10	0.45	24	72	14	2
Ohio M15	–0.08	26	75	5	1
W412A	–0.45	23	72	16	0
Funk G6	–0.45	20	66	15	2
Mass. 62	–0.96	25	68	24	0

[1] Significant difference at the 5 per cent level shown by dotted line.

Sweet-Dent Ensilage

By combining several late dent single crosses as seed parents with a large-stalked, large-eared, late, sweet corn inbred, C95, a series of sweet-dent hybrids which are suitable for ensilage has been produced. All of the ears of this new type of corn have a mixture of one-fourth wrinkled sugary kernels and three-fourths smooth dent kernels. This added sweetness in the kernels and tenderness in the stalks makes an ensilage that is more palatable than ordinary field corn, as shown by feeding trials. This type of corn is described in Station Circular 165.

Sweet-dent hybrids are characterized by a large, tall stalk, growing from 12 to 15 feet high on good soils in favorable seasons. The ears are enormous, from 15 to 18 inches long in the green stage. These large stalks are subject to breakage under heavy corn borer infestation and high winds. The following combinations have been selected for commercial production out of many tested and usually stand as well as the best field corn hybrids.

880	(Hy×C103) C95
881	(C102×C103) C95
882	(C106×C103) C95
883	(Oh40B×C103) C95
884	(T1×C103) C95

COMMERCIAL PRODUCTION OF HYBRID SEED CORN

The production of seed corn by crossing inbred strains has been described in numerous publications. Connecticut Station bulletins 273, 310, 361 and 518 and Storrs Circular 108 give information on both field and sweet corn. The United States Department of Agriculture bulletins 1489 and 1744 and recent publications of many state experiment stations give further information.

The production of hybrid seed corn is a highly specialized business requiring skill and experience and adequate equipment for the growing and processing of the seed at all stages. Much of the nation's sweet corn seed is now produced in the arid, irrigated areas of the Northwest, chiefly in Idaho. Field corn seed is produced largely where the corn is grown. Due to high production costs, the short growing season and heavy corn borer infestation, very little seed corn is now grown in New England.

The seed corn industry involves several important phases such as: the maintenance and increase of the inbreds; production of the single crosses used as seed and pollen parents; growing and processing the final double crossed seed.

After the inbreds have been reduced to uniformity and constancy, a process requiring about 10 generations of continuous selfing on the average, they can be increased in isolated fields by natural wind pollination. In this process off-type and outcrossed plants multiply more rapidly than the true-type inbreds. Consequently, stock seed cannot be maintained in this way for many generations even where careful field inspection and thorough removal of off-type plants is practiced before pollen is shed and the seed harvested. It is usually found necessary to maintain foundation seed by hand pollination, either self or sib. This foundation seed must be carefully inspected at all stages during the growing season and plants selected for trueness to type.

Most field corn inbreds are reduced to one-third or less of the productiveness of the original variety and are propagated with difficulty. They are extremely sensitive to low fertility and unfavorable seasonal conditions. It has been found necessary to produce inbred and single crossed seed under the most favorable conditions, increasing the usual amount of fertilization applied to grain corn from 50 to 100 per cent. Inbred plants can be grown more closely together since the plants are smaller and compete less for sunlight, soil moisture and fertility. The number of plants grown is often more than 50 per cent greater than the number of hybrid plants that could be produced on the same area.

Many inbreds are highly variable and many different strains of the same standard inbred are now being used. These variations arise from delayed segregation from a line having enforced heterozygosity, from outcrossing followed by backcrossing, and mutations. Some inbreds are much more stable than others. A preliminary comparison of 15 lines of Indiana Wf9 from different sources, all lines being separated for 10 or more generations, shows no appreciable differences. A collection of Illinois Hy lines from the same sources shows differences in every line. They differ in height of plant, time of flowering, color of anthers, glumes and silks, tassel type, and susceptibility to smut and leaf blight. When these different Hy lines are crossed, the increased seed production amounts to more than 100 per cent in many cases.

Figure 6. The amount of hybrid vigor shown by a cross of two sub-lines of Illinois Hy inbred. The two lines shown at top and bottom have been separated for at least 10 generations.

Purdue 39 sweet corn is also highly variable. Line crosses between different selections of P39 also show a large amount of heterosis and these line crosses are being used in the commercial production of sweet corn seed.

Line crosses are also used in field corn seed production. They increase the amount of pollen produced whereby inbreds can be used as pollinators in the production of three-way crosses. It is possible to produce commercial single crosses by using line crosses both for seed parents and pollen parents. Such a hybrid is produced in exactly the same way as a double cross but has much of the uniformity of a single cross.

Single crosses are produced in isolated crossing fields by planting two or three seed parent rows to one pollinator. Where four-row planters and cultivators are used, it is a common practice to put the pollinator seed in one planter box and the seed parent seed in the other three. This puts two pollinator rows together with six seed parent rows between. This is a long distance to spread pollen from an inbred and pollination may not be complete but this planting arrangement simplifies harvesting with a two row corn picker.

Planting in hills is a common practice to facilitate cultivation. It is difficult to find and remove off-type plants when corn is grown in this way, especially if the off-types produce tillers. From this standpoint, it is highly desirable to space the plants singly.

One of the most serious problems in seed production is the proper timing of the flowering periods of the seed and pollen parents. If inbreds are used that do not flower at the same time, the supply of pollen is insufficient to fertilize all of the silks, seed production is reduced and the kernels on the poorly filled ears are large and poorly shaped. In many cases it is necessary to plant one parent in advance of the other. This is difficult to do and increases the cost of both planting and cultivation.

Figure 7. Representative ears of three inbreds: I198, Oh07A and C107, all crossed by C103.

Figure 8. The single cross Ind. 38-11 × C103 combining large root growth with strong stalks.

Up to the present time no satisfactory methods of delaying germination or flowering have been developed. A small variation in flowering time can be made by fertilizing the seed and pollen parents differently. Large amounts of phosphorus with low nitrogen and potassium hasten flowering, while the reverse condition is said to retard this process. The results of fertilization tests do not give much evidence to support these claims. Moreover, any departure from normal growth reduces the yield and the full development of the seed kernel and is undesirable.

In order to spread pollen, it may be desirable to use the second generation of a single cross or a line cross for the pollinator. Such seed is easy to produce. If a thorough job of detasseling has been done, it may be saved from the pollinator rows of a production field. It has been shown theoretically, and actual tests bear this out, that seed produced by using the second generation of a single or line cross either as pollinator or seed producer, or both, is the same in productiveness and uniformity as that made from first generation hybrid seed. Second generation hybrid plants are highly undesirable as seed producers due to their greater variability and reduced productiveness but can be used to advantage as pollinators since there is a greater range in time of pollen production.

It has been found that the use of seed produced on pollinator plants grown in a foundation crossing field is undesirable. The seed parent plants are never completely detasseled. A production field may also have many off-

type plants which cannot be removed entirely before pollen is shed. If such seed is used, it had better be grown as a seed parent. In this way any off-type ears can be thrown out when the crop is sorted.

Pollinators are frequently increased by planting additional rows at one side of a crossing field. If this field is well removed from other corn fields, such seed is usually all right.

It is desirable to increase inbreds and produce foundation single crosses in as large fields as possible. In this way there is less danger from contamination by pollen from other corn fields. Small isolated fields are subject to many hazards from predatory animals and are so hard to reach that they are frequently neglected at critical times.

By controlling temperature and humidity in storage, seed corn can be kept in a viable condition for many years. This reduces the danger of contamination and variation due to mutation. The advantage of having an abundant supply of tested foundation inbreds and single crosses justifies the installion of good storage facilities. In storing seeds, thorough drying and low humidity are more important than low temperatures. However, with optimum moisture conditions, low temperatures prolong the life of the seed.

By increasing the number of plants grown, applying additional fertilization, irrigating at critical periods and removing the pollinator plants as soon as pollen is shed, it is possible to increase the production of single crossed seed materially. The production of inbreds and single crosses is rapidly becoming a specialized business. Many producers of double crossed seed regularly purchase their single crosses from foundation seed growers. Such producers are limited to standard hybrids available to all seed growers.

Most of the final double crossed seed is grown on contract. The seed producer supplies the seed and frequently does the planting and detasseling.

Figure 9. The single cross of C102 $\times$ C103, two Lancaster Surecrop inbreds, combining high grain yield with strong stalks. This is a pollinator for many Connecticut hybrids.

The grower cultivates, harvests the crop and delivers the crossed seed to the warehouse for drying and processing. The seed grower keeps the corn produced on the pollinator rows for feeding on the farm or for sale as grain. He may also sort out all off-type and defective ears not suitable for seed or have these returned from the warehouse for feed.

Much of the value of hybrid seed corn as now produced comes from the thorough and efficient drying, grading, and treatment with fungicides for seed borne diseases. It is generally considered that these advantages alone justify the production of seed by specialized seed growers. Seed produced in this way can be planted to give uniform stands of plants and the seeds germinate vigorously even under unfavorable conditions. However, the greatest value of hybrid corn comes from the control of valuable germplasm, combined in such a way as to gain the full advantage of hybrid vigor. Corn breeders are constantly striving to produce better inbreds which will not only be easier to grow as inbreds but will give still better results in the final hybrid combination grown by the farmer.

THE PRODUCTION OF HYBRID SEED CORN WITHOUT DETASSELING

Following the discovery in 1923 of a recessive gene producing sterile pollen, which was closely linked to the yellow-white endosperm color gene, it was realized that this heritable character could be used for the production of hybrid seed corn without detasseling. By backcrossing, this sterile pollen condition could be incorporated in any inbred or single cross used in the production of seed. It was first incorporated into a segregating yellow and white flint of the Canada yellow type to be used as the seed parent of the Canada Leaming hybrid. Later it was put into Indiana Wf9 yellow dent and Purdue 39 sweet corn. To utilize this method, it was necessary to separate seeds by color. It is possible to produce both a white and a yellow sterile seed parent, propagating the sterile inbred by backcrossing. The production of an all-yellow sterile seed parent was somewhat more difficult than the production of a white-seeded hybrid but it has been done by linking the sterile tassel with the dominant yellow endosperm and backcrossing with a similar type with the fertile tassel gene linked with the colorless endosperm gene. After backcrossing, the seeds are separated into dark yellow with sterile tassel and light yellow with fertile tassel and the dark yellow seeds only used for seed production.

It was found that complete separation based on color was difficult. Fertile tassels resulted from seeds improperly classified, from crossing over and from hetero-fertilization, where the endosperm differs in genetic constitution from the endosperm. For all these reasons the use of the gene sterile type for the production of hybrid seed has not been used in commercial practice up to the present time. Further investigations are under way that may make this process feasible.

In the meantime the discovery of the cytoplasmic type of pollen sterility made possible a method that is now being used successfully. Cytoplasmic sterility in corn was first described by Rhoades in 1933. This condition originated in a South American variety of corn collected by R. A. Emerson and F. D. Richey and grown at Ithaca, N. Y. A similar character was also found by P. C. Mangelsdorf in Texas in 1936. This occurred in a cross of a late yellow field corn with a white sweet corn. This Texas corn showed a more

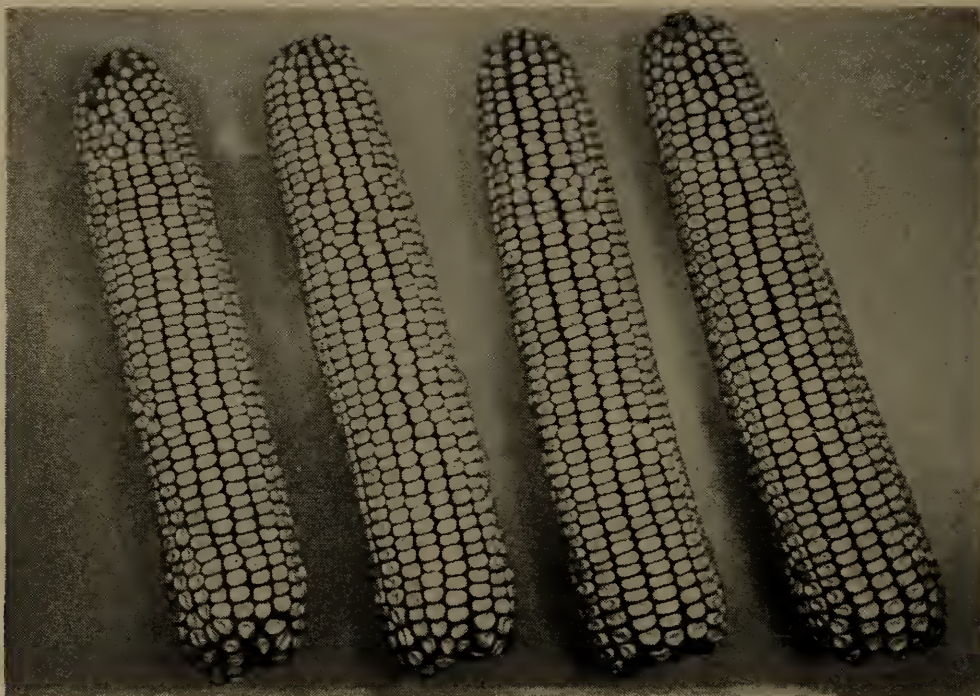

Figure 10. The test cross of Ind. Wf9 and C103, one of the highest yielding single crosses.

stable type of complete sterility when incorporated into standard inbreds than that described by Rhoades and has been used in the production of inbred strains suitable for commercial production of seed.

Cytoplasmic pollen sterility is brought about by something outside of the chromosome mechanism. It shows only maternal inheritance and is independent of the genes within the chromosomes. Sterile plants, for the most part, remain sterile when crossed by normal fertile plants generation after generation. The sterile condition can be incorporated in any inbred and apparently does not affect deleteriously the plant in any other way than in curtailing its ability to produce viable pollen. Fertile and sterile inbred plants of the same genetic constitution are apparently identical in size, time of maturity and structural details. The ability of the sterile plants to transmit their inherited characters to their hybrids is equal to the fertile plants in all respects except pollen production.

It is, therefore, a simple matter to incorporate this cytoplasmic sterility in one of the inbreds used as the seed parent of a single cross. This pollen sterile single cross can then be used as the seed parent of a three-way or double cross hybrid.

To restore fertility in the final crop grown for grain production, it is necessary to mix seed of two types, one producing normal tassels, the other sterile tassels, in the right proportions to insure a normal set of seed. Usually one-fourth fertile plants is adequate. The normal and sterile types used in this mixture may be of the same or different genetic constitution, but, of course, must produce pollen at the right time to fertilize the sterile plants.

Preliminary experiments indicate that both seed production and grain production are increased by using these sterile plants. Much of the energy that normally goes into pollen production is diverted to seed production.

In seed production fields, where the tassels are pulled out, there is considerable injury to the plants by the mechanical operation of going through the field to remove the tassels. Frequently, one or more leaves are pulled with the tassel or are injured. It has been shown that every leaf that is removed or injured reduces the yield of grain by an appreciable amount. Smut and other diseases frequently become established where the tassels are removed.

It is also possible to produce seed-sterile corn plants with normal pollen. This method has been described in the production of dioecious corn (Jones, 1934) by using two recessive genes ts_2 and sk. The double recessive combination ts_2 ts_2 sk sk produces seeds in both the terminal and lateral inflorescences. By crossing ts_2 ts_2 sk sk by normal silkless Ts_2 Ts_2 sk sk, all of the progeny has normal pollen-producing tassels and completely sterile ears. By incorporating these genes in any standard pollen parent inbred and using this as the source of pollen, it is possible to produce hybrid corn without planting in alternate rows and without detasseling. All that is needed is to mix the seed of the pollen-sterile seed parent with the seed of the seed-sterile pollinator in the proper proportions and harvest the entire crop for seed. Such types have been produced in experimental cultures and the final double crosses tested for yield.

At the present time the use of the seed-sterile pollinator is considered to be too complicated to be used in commercial seed production. It is difficult to incorporate two recessive chromogenes in standard inbreds without altering their composition in other ways. By mixing seed, it is not possible to remove off-type and out-crossed plants. Furthermore, all of the pollen

Figure 11. Representative ears of Connecticut hybrid 830, characterized by high yields, low stalk breakage.

producing plants are barren of seed, thereby increasing the cost of seed production somewhat.

Much to our surprise it was found that this seed-sterile pollinator carries the ability to overcome, to a considerable extent, the pollen sterility of the cytoplasmic sterile seed parents with which it has been used. It has been found that the degree of sterility in the final crossbred progeny can be modified appreciably by the genetic constitution of the pollinator. The seed-sterile pollinator carrying the recessive ts_2 and *sk* genes has this ability to a high degree. Whether this is a property of either or both of these specific genes, or is due to other genes derived from the same source, has not been determined.

All of the evidence at hand indicates that the cytoplasmic sterility can be used successfully in the commercial production of hybrid seed corn and that seed setting can be insured either by mixing seed to furnish the required amount of pollen or by incorporating in the pollinator the necessary genetic constitution to overcome the sterility sufficiently to produce a normal set of seed. It has been found that many inbreds have this ability and that it can be intensified by selection.

This new method of seed corn production has been developed by the senior writer in cooperation with Dr. P. C. Mangelsdorf, a member of the staff of this Station when these investigations were started. Further details concerning the development and application of pollen sterility to seed production will be given in a later paper to be published jointly.

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